



# Fracture Control Requirements for Composite and Bonded Structures



## Why Develop a New Requirements Document?

- Current requirements are top level or specific to shuttle payloads.
  - NASA-STD-5007 top level requirement that imposes fracture control on all manned spaceflight hardware.
    - Composites addressed at very top level.
  - NASA-STD-5003 imposes fracture control on payloads for the space shuttle.
    - Imposes fracture control on composite and bonded structures.
    - Silent on many important issues such as post proof NDE, residual strength, and reuse.
    - Not adequate for or directly applicable to next generation of spacecraft.



# Fracture Control Requirements for Composite and Bonded Structures

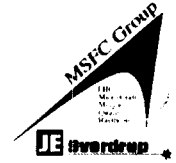


## New Requirements Document Scope

- NASA Policy.
  - Fracture control is required for safety of manned spaceflight.
- Hardware scope.
  - Manned spaceflight hardware including manned launch, transport, and landing vehicles, space habitats, and payloads.
- Materials/structures types.
  - Covered by new standard:
    - Polymer and carbon matrix composites.
    - Sandwich construction.
    - Bonded metallics, bonded composites, or bonded metallic-composite.
  - Specifically (currently) excluded by new standard:
    - Metal and ceramic matrix composites.
    - Foam.
    - Flexible inflatable structures.
    - Liquid rocket engines.



# Fracture Control Requirements for Composite and Bonded Structures



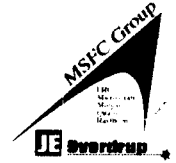
## New Requirements Document Development Approach

- Review other requirements in addition to NASA ones:
  - Aircraft – Military – JSSG 2006
  - Aircraft – Civil – FARs/MIL-HDBK-17F
  - ISO/CD 21347 (Draft 123102)
  - TOR-2003 (7894)-X

} Under development by Aerospace Corporation
- Aircraft generally require extensive building block test programs beyond what NASA can realistically afford for one-of-a-kind or a “few” vehicles.
- Account for “less building block testing” with more stringent requirements on the tests that are required.
- Cast in the framework and language of existing NASA fracture control requirements.
- Address the shortcomings of existing NASA fracture control requirements.
- Rely on ANSI/AIAA S-081-2000 for COPVs.
- Refer to MIL-HDBK-17F and TOR-2003 (7894)-X for specific methodologies.



# Fracture Control Requirements for Composite and Bonded Structures



## Classification of Composite Parts and Bonds for Fracture Control

A part (or bond) is fracture critical if its failure due to the presence of a flaw would result in a catastrophic hazard. All composite parts and bonds shall be classified according to the following:

### **Exempt**

- Non-structural and no safety critical function

### **Non-Fracture Critical**

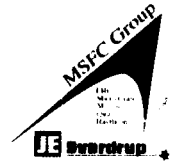
- Low released mass
- Fail safe
- Contained
- Low risk
- Non-hazardous leak before burst (NHLBB)

### **Fracture Critical**

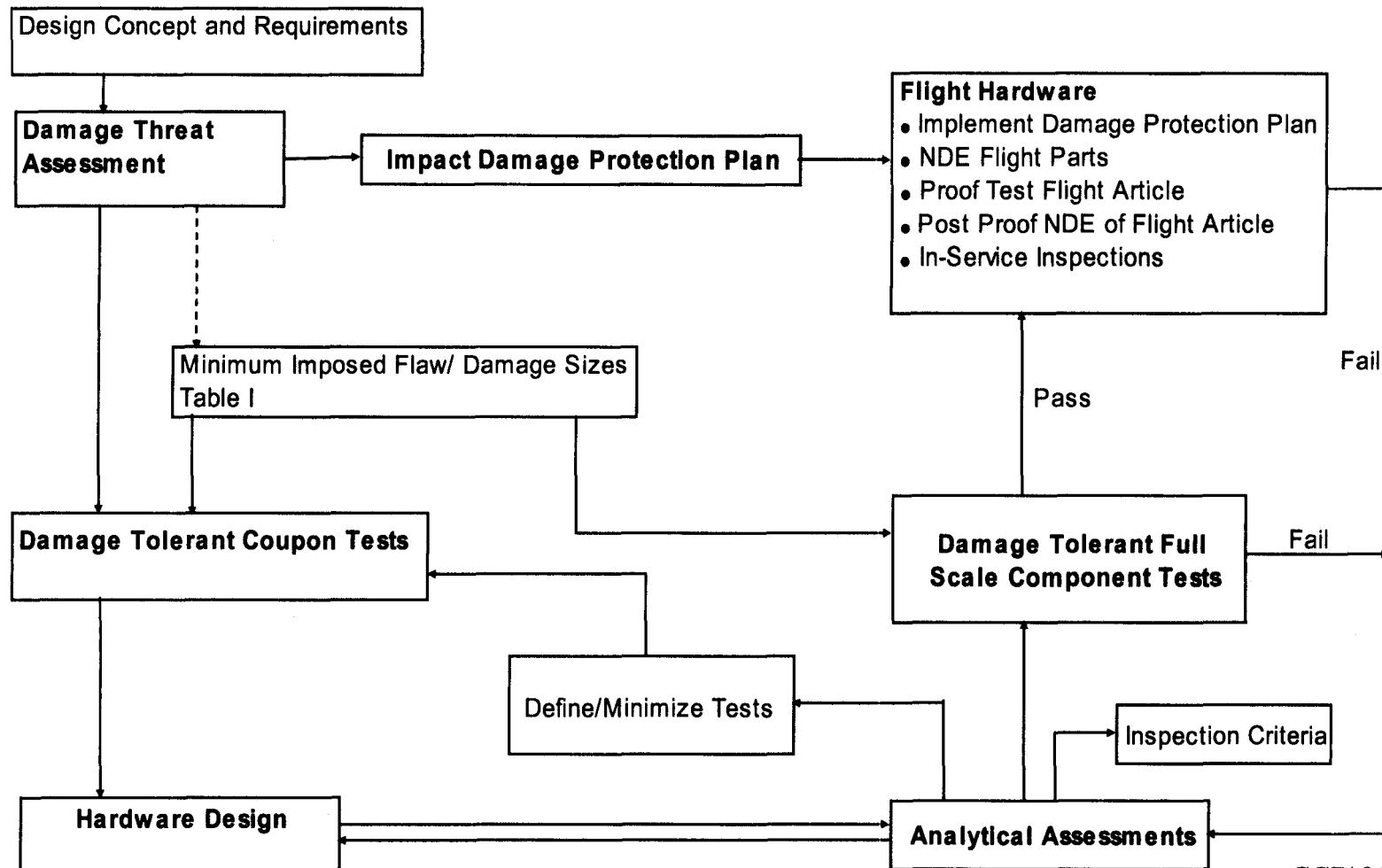
- Proofed
- Damage tolerant



# Fracture Control Requirements for Composite and Bonded Structures

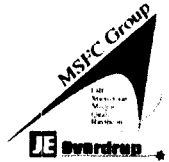


## Steps in Establishing Damage Tolerance

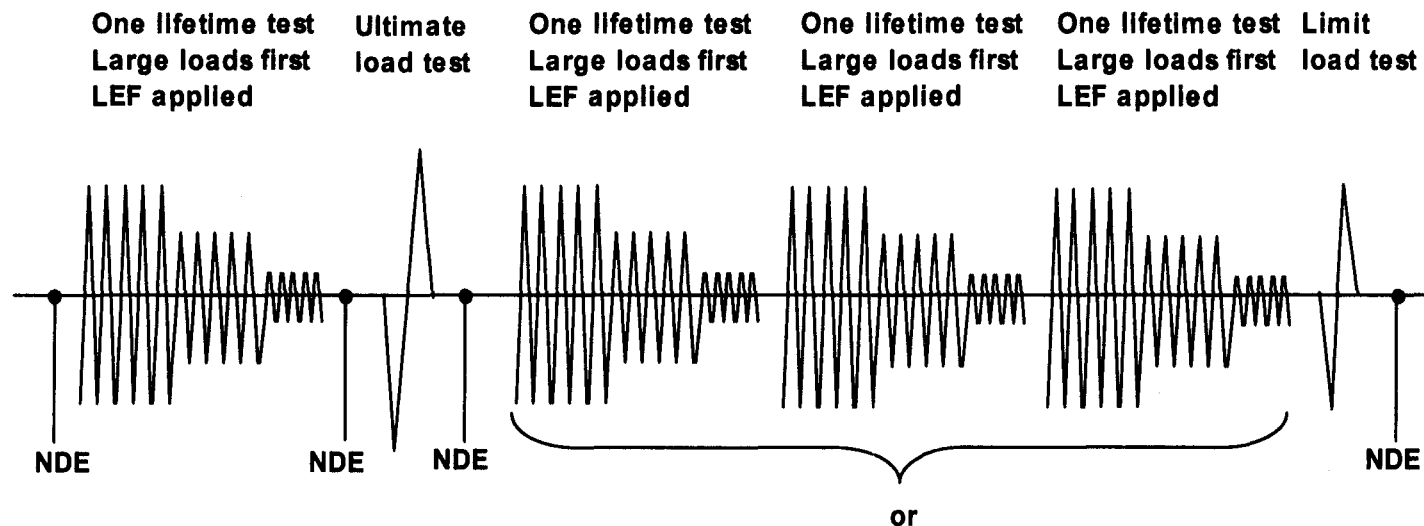




# Fracture Control Requirements for Composite and Bonded Structures



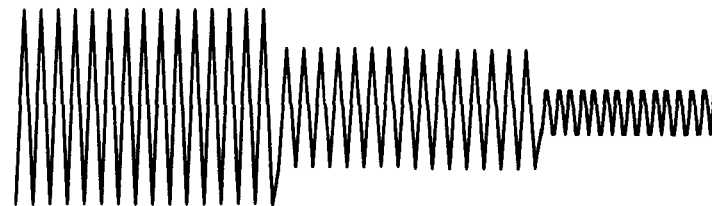
## Damage Tolerant Full-Scale Component Test



### Notes:

1. Environmental correction factor (ECF) applied as appropriate.
2. Truncation allowed for cycles below threshold.
3. Special visual inspection required along with NDE.
4. Proof test loads are to be included in lifetime definition.
5. No flaw growth allowed at end of first lifetime.
6. No flaw growth allowed at end of ultimate load test.
7. No structural failures allowed at any time.
8. Structure must be capable of performing all its functions at the end of all tests.
9. LEF = Load enhancement factor.

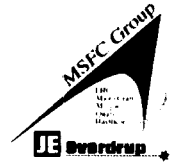
Three lifetimes test  
Large loads first  
LEF applied





# Fracture Control Requirements for Composite and Bonded Structures

---



## Next Steps for New Requirements Document

- Currently reviewing with the MSFC Fracture Control Board.
- Review with and update per the NASA Fracture Control Analytical Methodology Panel.
- Submit to NASA Standards Group for formal review and publication as a NASA Standard.